DOCUMENT RESUME

ED 479 630 IR 022 235

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TITLE	Tools of the Web-Based Learning Trade.
PUB DATE	2002-10-00
NOTE	7p.; In: E-Learn 2002 World Conference on E-Learning in Corporate, Government, Healthcare, & Higher Education. Proceedings (7th, Montreal, Quebec, Canada, October 15-19, 2002); see IR 022 093.
AVAILABLE FROM	Association for the Advancement of Computing in Education (AACE), P.O. Box 3728, Norfolk, VA 23514. Tel: 757-623-7588; e-mail: info@aace.org; Web site: http://www.aace.org/DL/.
PUB TYPE	Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01 Plus Postage. PC Not Available from EDRS
DESCRIPTORS	*Computer Assisted Instruction; *Distance Education; Educational Research; *Educational Technology; Higher Education; Instructional Design; Instructional Effectiveness; *Instructional Materials; Learning Activities; World Wide Web

ABSTRACT

The focus of this paper is Web-based learning environments and the tools that can support learning. The paper suggests that tools affect learning, and examines how this information should influence the Web-based learning environment. The paper begins with a theoretical foundation of tool effects on people, followed by a summary of research on the effect of computer tools in education. The tools of Web-based learning are then described, followed by two examples (in a graduate and an undergraduate course) of effective use of tools in Web-based learning environments. Implications for designers of Web-based learning environments are presented. (Contains 24 references.) (AEF)

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Title: Tools of the Web-Based Learning Trade

Introduction

Tools have been integral to all advances of humans since the beginning of time (Rosenberg, 1976). Tools of the agricultural age were the ploughs, the industrial age was the metal implements, and the information age is the computer. These tools helped in the advances of mankind by improving productivity as well as changing the nature of the tasks. Rosenberg (1976) suggests that the fundamental unit of change in all tool effects is how each individual learns to use the tools, improves the use of the tool, and invents new tools resulting in economic development over time. Following that same thinking to the information age focuses our attention on the computer as THE tool of our day. Computer tools have become a part of everyday life today and has become the key to work, play, and learning activities. We use computer tools like databases, spreadsheets, and the World-Wide-Web in most activities today.

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The focus of this paper is web-based learning environments and the tools that can support learning. This paper argues that the tools of web-based learning should be the tools that support problem solving and not the tools of course management.

We begin with a theoretical foundation of tool effects on humans, overview of research on how computer tools affect learning and how this information should influence the web-based learning environment, and conclude with two examples of computer tools used in web-based learning.

Theory - The *Effect Of* and *Effect With* Tools

Pea (1985) presented two components of tool effects on humans. First, he suggested that as humans use tools for their activities the tool leaves a cognitive residue on the person using it. This cognitive residue was termed the "*effect of*" computer tools. Salomon et al. (1989) presented findings that showed how learners internalized prompts from a reading partner to improve their reading and monitoring/understanding skills. As learners were given prompts to attend to the main points of the reading, they were able to improve their understanding of the material and were able to transfer the skills to other reading activities. Here the *effect of* the tool was the students' display of the monitoring skills prompted by the reading partner.

Second, humans solving problems with tools is described as the *effect with* tools (Pea, 1985). The *effect with* tools is a complex phenomena where humans can off-load working memory intensive mental activity to a computer tool and concentrate on higher-order thinking and the tool provides an affordance to the activity. Off-loading is a simpler concept where users can overcome limitations of working memory by allowing a spreadsheet to do calculations while they concentrate on higher order activities like hypothesis testing (Salomon, 1990; Salomon et al. 1991). Affordances on the other hand are complex interactions that are affected by the tools, the prior knowledge of the users, and the types of activity where the tool is being used (Gibson, 1966; Greeno, 1994). For

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example, Zhang (1997) showed that users are affected by the presentation modes and think that one type of Tic-Tac-Toe presentation is more complex than others. Similar findings were report by Kozma & Russell (1997) where younger novice learners were more affected by representations of problems than experts.

The combination of the *effect with* and *effect of* tools has very important implications for the design of web-based learning environments. The computer tools can and do have lasting impacts on the knowledge structures of learners, and these experiences have the potential to affect their future work and learning activities. The research supporting this theoretical framework is described next.

Research - A Summary

The *effect of* computer tools have been studied in the areas of reading (Salomon et al. 1989), writing (Salomon, 1993), mathematics (Adams & Shrum, 1990; Dixon, 1997), science (Roth, 1995), and many others. The findings of these studies are mixed. Wijekumar & Jonassen (2002) presented findings showing how the *effect of* long term computer tool use was evident in experts' problem schemas, approach to problem solving, and the solutions as well.

The *effect with* computer tools also has some very relevant findings. Wijekumar & Jonassen (2002) report how experts interacted with the computer tool to off-load some mental activities like calculations, graphing, and statistical analysis, while they concentrated on identifying the possible factors that explain the results as well as comparing the results from different types of analysis. Roth et al. (1996) however showed that younger learners had difficulty in using the tools because they lacked the prior knowledge and knowledge of the tool's use to effectively accept the affordances provided by the tool.

In summary, research has shown that computer tools do leave a cognitive residue on its users in their problem schemas and knowledge structures. It is also becoming evident that the tools interact with the users providing very complex affordances which are dependent on the prior knowledge and experiences of the users. Based on the research reviewed the following are critical aspects of computer tool use in educational settings.

1. The tool(s) will leave a cognitive residue on the learners
2. The tool(s) should provide the scaffolds and support the learning process as it relates to the goals and objectives of the learning environment and tasks.
3. The tool should also be introduced to help the learners learn and as an assessment tool. It should not be assumed that learners have the domain knowledge and/or tool skills to use the tool effectively.

Given the state of theory and research on computer tools in human activities do we have the right tools in our web-based learning environments?

Web-Based Learning - The Tools

The current rage in web-based learning environments is the use of course design and management systems that are sometimes also referred to as learning management systems. Examples of these products include WebCT, BlackBoard, etc. These environments provide a general framework to allow designers and professors to create on-line courses which contain notes, multiple choice tests, essay tests, links to web sites, chat rooms, bulletin boards, and email. While these are some tools for creating web-based learning environments, they are frequently the only tools available to designers, professors, and learners. A review of any journal on web-based learning and/or papers on the topic shows a variety of topics on comparing web-based courses with in-class courses, studying the discussion contents of bulletin board postings, and analyzing interactions of learners using the same.

Reading these papers makes one want to believe that learning can occur through reading notes, conversations (bulletin board and chat), and/or multiple choice tests only! Tools have been shown to leave a lasting imprint on the knowledge structures of learners and this impact affects future problem solving as well. If students were reading notes, posting comments, and taking tests, what types of knowledge structures can they be expected to have? Are they using the tools that are appropriate for the task? How are they using them? What scaffolds are being used with the tools?

In light of the research and theory discussed in this paper it should be obvious that these web course management tools do not address these concerns and they are not and should not be the only tools of the trade for a web-based learning environment. To be an effective environment for learning it is critical to address the following factors:

1. The right tool for problem solving must be used by the learner
2. The correct scaffolds and help for using the tool should be available to the learner
3. The assessment of the learning should include the use the tool.

Next we present two examples of how tools can be integrated into web-based learning environments to facilitate learning.

Examples of Effective Use of Tools in Web-Based Learning Environments

Case 1

A graduate level course on management economics requires students to analyze data on employee performance to recommend a reward program for a company. As part of the case students on the web are required to read the literature on performance factors as well as incentive and rewards programs. The next step is to provide the student with a statistical analysis tool to perform the analysis themselves.

As part of the course design a Filemaker Pro database was linked to the case study and instructions and guidance was given on the use of the tool. The student was also able to keep open two windows, the first with the database/analysis tool and the second which contained instructions and feedback based on their responses from the analysis.

The important points in this example is that the users had access to a real tool which was used as part of their problem solving activity. They also responded to questions in the second window which was written using a CGI-SCRIPT so that they could submit answers to the system and get automatic feedback on their answers as well as possible next steps. This combination provided the students with the correct tools as well as the scaffolding necessary to use the tools.

Case 2

An undergraduate level course on distributed programming provided a comprehensive enterprise level development environment linked to the course. This environment used open source software Ant, Tomcat, Jboss, XML, and HTML, which was structured so that learners could build, deploy, and test their enterprise application using Java™ in a controlled setting with scaffolds. For example, the learners were given written guidelines and a tutorial on creating, testing, and deploying servlets and linking the servlets to web pages. The students used the pilot environment to develop their solutions using multiple levels of input from the system as well as the instructor, and colleagues. The users had access to the complete sets of instructions, examples of deployed servlets, hints, and access to logs. The environment was set up with secure access from anywhere using a Secure Shell Application and Protocol.

Implications for Designers of Web-Based Learning Environments

The examples presented here were designed to showcase how computer tools can and must be incorporated into web-based learning environments to support the most realistic problem solving environment. The choice of tools depends on the tasks and objectives of the course.

The current array of web-based course management tools are not sufficient to develop a learning environment that supports the construction of problem solving and other complex skills. It should be the designer and/or creators responsibility to identify the tools required and choose the interfaces as well as the implementations that will seamlessly provide access to those tools.

The access methods described in this paper required programming expertise in web related programming and markup languages like html, xml, CGI scripts - Perl, and understanding of the hardware requirements for supporting the course content, layout, and delivery. Building scaffolds adds another level of complexity by requiring a complex thought process on how novices learn, identifying the types of hints they will need, and designing the interface that will provide the scaffold and not be too intrusive in the learning process.

Conclusion

As shown in the examples, the tools of web-based learning should be chosen based on the goals of the course and individual objectives. If a student in a web-based course is learning to create an incentive plan for employees of a company, then they

should be given access to the tools that facilitate the tasks that support the objectives. If a student is learning to create a web-based bookstore then they should have the tools and resources necessary to create programs, test them and showcase them. These and many other examples in human services, Physics, Mathematics, and Law will be presented at the conference to showcase how we can improve the cognitive residue of our web-based learning environments and change the nature of the tasks by allowing the learners to off-load mental work to the tool and accept the affordances provided by the tools. These should be the tools of the web-based learning trade.

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